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Fire Related Considerations and Strategies in Support of Ecosystem Management

Staffing Paper

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Fire and Aviation Management

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Executive Summary

Ecosystem Management is a new policy initiative that more fully integrates ecological principles and processes into Forest Service activities. Applying this new policy to Fire Management will present fundamentally important challenges and opportunities. Across National Forest System lands, the biological effects of fire have a profound influence on composition, structure, and function of forest and grassland ecosystems.

This paper directs attention to short interval fire-adapted ecosystems because they are often the first indicator of a potentially larger problem. In these ecosystems, in the absence of periodic low-intensity surface fire, stands undergo relatively rapid changes in species composition and structure which, in turn, often become predisposing factors to epidemic insect and disease outbreak and severe stand replacement wildfire. In these ecosystems, under these conditons, managers are finding it difficult—if not impossible—to ensure sustainability. Sustainability is among the legislated mandates that direct Forest Service activities and is a key element of Ecosystem Management.

Expanding the prescribed fire program seems a simple and biologically sound way to restore sustainable conditions and help solve forest health problems in fire-adapted types. However, the use of prescribed fire—especially on a landscape scale—presents managers with a serious dilemma: Although fire regulates the biotic productivity and stability of fire-adapted ecosystems in ways that cannot be fully emulated by mechanical or chemical means, the negative effects of smoke and the risk of consequences inhibit its use.

Sustaining short interval fire-adapted ecosystems, in particular, is emerging as an important agency challenge. Remediation efforts will encounter significant problems. However, avoiding treatments creates serious consequences:

- Change from relatively low damage, stand-maintenance fires to more severe high damage, stand-replacement fires.
- Conversion from fire-resistant species to fire-intolerant species having less resilience to fire disturbances.
- Less controllable and more costly wildfires.
- Increasing danger to firefighters.
- Growing threat to wildland/urban interface values where development is occurring in fire prone types.
- Increasing potential for higher particulate matter emissions as fuel loads and understory biomass increase.

Aggressive fire suppression must remain an essential cornerstone of the Forest Service mission. Concurently, however, Fire and Aviation Management must position itself so that it can effectively respond to the challenges of Ecosystem Management.

Five recommendations are made:

1. Establish a dialogue that provides fire related information to our publics and our decision makers, enabling them to make more informed judgments. Develop a concise, scientifically sound message about fire's ecological role and deliver it clearly, both internally and externally.

2. Retain a service and support orientation within the Fire Management community, but take an earlier, more active role in the land management planning process.

- Integrate fire related considerations into forest plan alternatives, goals, and objectives. Include display of long-term effects associated with fire use and fire protection programs on attainment of forest plan objectives, and

- Document effects of implementation in the monitoring and evaluation phase of forest plan execution.

3. Continue to strengthen the concept of total Fire Management by increasing prescribed burning expertise while maintaining strong fire suppression capabilities.

4. Institutionalize an operational risk assessment and mitigation strategy at the local level in support of prescribed fire treatments. Include a determination of escape thresholds and identification of high risk factors that trigger or contribute to escaped prescribed fires.

5. Maintain a programmatic diversity in Fire Management, but better align prevention, suppression, hazard reduction, fire use, and fire rehabilitation efforts to more fully complement one another in support of Ecosystem Management.

Introduction

Ecosystem Management is a new policy initiative that more fully integrates ecological principles and processes into Forest Service activities. For Fire Management, this new policy will present fundamentally important challenges and opportunities. Across National Forest System lands, the biological effects of fire have a profound influence on composition, structure, and function of forest and grassland ecosystems. The potential benefits of fire restoration must be considered in land management plans that are responsive to Ecosystem Management.

For the past several decades, Forest Service management practices have reflected a strong emphasis on protection and commodity production. Although these practices were widely supported and well intentioned at the time, the results of prolonged fire exclusion, selective overstory logging, and livestock grazing have certainly changed today's forests, some more than others.

The Blue Mountains in northeastern Oregon and southeastern Washington, the Colorado Front Range west of Denver, the central Sierras in California, and the mountains of southern Idaho are all areas where significant changes in stand characteristics have occurred. In these areas, serious forest health problems have developed as a result of past uses and management practices. Without treatment, other geographic areas havings similar physiographic feaures will likely manifest the same problems over the next several years.

Forest health problems appear to be most concentrated in short interval fire-adapted ecosystems, commonly represented by long-needle pine types. These types include ponderosa, Jeffrey, eastern and western white, red, loblolly, short-leaf, long-leaf, and slash pine species. As a measure of scale, these pine types, as either dominants or in association with other species, are estimated to occur on nearly 30 percent of the suitable timber base on National Forest System lands.

Although fire is an important process in a variety of forest, brush, and prairie ecosystems, it may be most critical in the long needle pine types. In these short interval fire-adapted ecosystems, in the absence of periodic low-intensity surface fire, stands undergo relatively rapid changes in species composition and structure which, in turn, often become predisposing factors to epidemic insect and disease outbreak and severe stand replacement wildfire. In these ecosystems, under these conditions, managers are finding it difficult—if not impossible—to insure sustainability. Sustainability is among the legislated mandates that direct Forest Service activities and is a key element of Ecosystem Management.

Notably, in the Southern Region where large-scale prescribed burning has occurred in short interval fire-adapted types since the 1930's, forest health problems are much less extensive, when compared to those nationally.

Expanding the prescribed fire program seems a simple and biologically sound way to restore sustainable conditions and to help solve many forest health problems in fire-adapted types. However, the use of prescribed fire—especially on a landscape scale—presents managers with a serious dilemma: Altough fire regulates the biotic productivity and stability of fire-adapted ecosystems in ways that cannot be fully emulated by mechanical or chemical means, the negative effects of smoke and the risk of consequences inhibit its use.

Further compounding the dilemma is a caution against a rushed reintroduction of fire in long-needle pine types where high fuel loadings and multistoried canopies have developed in the prolonged absence of fire. Under these conditions, chances increase that burning will exceed acceptable risk. Without intermediate understory treatments, managers will experience an unacceptably high number of escapes or will be forced to constrain burning windows to the extent that sizeable acreage cannot be treated.

Sustaining short interval fire-adapted ecosystems, in particular, is emerging as an important agency challenge. Although it's clear that treatment efforts will encounter significant problems, avoiding treatment is not without serious risks:

- Change from relatively low damage, stand-maintenance fires to more severe high damage, stand-replacement fires.
- Conversion from fire-resistant species to fire-intolerant species having less resilience to fire disturbances.
- Less controllable and more costly wildfires.
- Growing threat to wildland/urban interface values where development is occurring in fire-adapted types.
- Increasing danger to firefighters.
- Increasing potential for higher particulate matter emissions as fuel loads and understory biomass increase.

Aggressive fire suppression must remain an essential cornerstone of the Forest Service mission. Escalating commodity and amenity values and increasing private development at the wildland/urban interface all indicate the need to maintain or strengthen firefighting capability. Figure 1 shows the relationship between successional development and fire protection capability. As stands evolve past late seral stages, our ability to protect them diminishes. We must recognize this in our fire protection strategies. Concurrently, Fire and Aviation Management must position itself so that it can effectively respond to the challenges of Ecosystem Management. Sustaining multiple-use benefits in fire-adapted systems is a challenge that calls for the development of a coherent, comprehensive strategy.

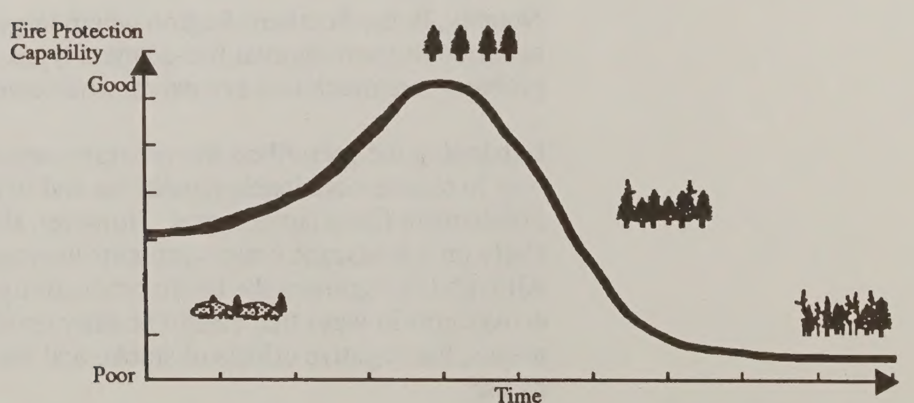

Figure 1. Typical Fire Protection Capability in Short Interval Fire-Adapted Ecosystems

Objectives

Our purpose is to recommend a course of action that better positions Fire Management in support of Ecosystem Management. This paper identifies major fire related issues that are expected to affect implementation of Ecosystem Management and outlines a strategy that attempts to reconcile management challenges surrounding short interval fire-adapted ecosystems.

Key Related Issues

The National Forest Management Act and the land management planning process provide the means for the Forest Service to identify, weigh, and resolve issues and concerns.

There are important external, as well as internal agency issues that need to be resolved in order to successfully manage fire-adapted ecosystems. The complexities involved in sustaining fire-adapted ecosystems will challenge fire managers to more thoroughly assess and communicate expected fire related benefits, risks, and losses in the land management planning process.

Social and Regulatory Issues

- Ecological concepts that establish the basis for informed decision making in support of Ecosystem Management have, historically, not always been a part of the land management decision process. These concepts are not well communicated within the agency nor fully understood by the general public.

- Mistakenly, ecosystems are often perceived as static, rather than dynamic.

- Landscape scale prescribed fire applications may come into conflict with the Federal Clean Air Act. More stringent EPA regulations could increase conflicts. There is also the potential to come into conflict with the Endangered Species Act in some cases.

- The highly successful Smokey Bear campaign is the agency's only fire related message to the public. The agency does not portray fire's importance in maintaining healthy ecosystems.

- Risk is an inherent part of prescribed burning. The uncertainties surrounding prescribed burning in wildlands are considerable and are not always subject to effective management control. Escapes will occasionally occur without negligence on the part of the agency but could erode public support and diminish agency support for an expanded fire-use program.

- The Federal Tort Claims Act, as currently applied, does not afford claimants expedient reimbursement in the event of loss resulting from prescribed fire escapes. The cumbersome process of reimbursement may be a serious impediment to full implementation of prescribed fire in Ecosystem Management.

Technological Issues

In general, as a result of changes in vegetative stand structure and species composition in short interval fire-adapted ecosystems, periodic high-intensity, stand-replacement fires have displaced frequent low-intensity, stand-maintenance fires.

- Present vegetative stand characteristics often impede managers' ability to use prescribed fire within reasonable limits of risk or within the range of a species' or system's ability to respond or recover.

- Pre-burn vegetative/fuel management actions may be needed to incrementally reduce hazard and allow for prescribed fire use in some areas, but mechanical or chemical treatments might be controversial and may be difficult to accomplish on landscape scales.

Economic Issues

- In short interval fire-adapted ecosystems, hazards are commonly due to encroaching understory fuels. Reduction of these fuels, which are usually sub-merchantable, will be expensive. Although timber harvesting has been presented as an economically efficient means of managing wildfire potential, recent research indicates that some forms of harvest without adequate fuel treatments in some fuel types do not reduce hazards, but exacerbate fire related problems (Weatherspoon and Skinner, in preparation).

- Economic evaluations tend to focus on short-term costs and losses. Appropriate analysis of long-term investments are needed.

Internal Issues

- Increasing values-at-risk will continue to build public expectations for strong protection and fire suppression programs.

- Functionalism in the Forest Service may impede Ecosystem Management including landscape-scale prescribed burning. The short term focus of management tends to encourage the protection of functional interests, potentially at the expense of ecosystem health.

- A landscape-scale reintroduction of prescribed fire will require a significant change from present funding and reporting strategies. Implementation will require a redirected budget emphasis, multifunctional financing, and/or improved efficiencies. Reporting systems will need to be compatible.

- Fire managers and line officers often lack training in ecological principles and processes. The lack of knowledge impedes their ability to recommend feasible alternative actions or make informed decisions. Ecological classification systems (and accompanying management implications) are frequently under-utilized or altogether overlooked.

- Fire managers and line officers lack training in social impact assessment and social mitigation strategies.

- Two distinct skill areas have evolved in Fire Management. On-the-ground intuitive expertise and desk-bound analysis are equally important to the mission; however, very few individuals have skills in both areas or appreciate each other's value. As a consequence, applications tend to run independent of supporting analysis and analysis tends to occur without benefit of field verification.

Recommendations and Actions

Five recommendations follow. Each recommendation is accompanied by a brief statement of management's intent, a description of the tools necessary for implementation, and an action plan that identifies those responsible for implementation and the target date for completion.

1. ESTABLISH A DIALOGUE THAT PROVIDES FIRE RELATED INFORMATION TO OUR PUBLICS AND OUR DECISION MAKERS, ENABLING THEM TO MAKE MORE INFORMED JUDGMENTS. DEVELOP A CONCISE, SCIENTIFICALLY SOUND MESSAGE ABOUT FIRE'S ECOLOGICAL ROLE AND DELIVER IT CLEARLY, BOTH INTERNALLY AND EXTERNALLY.

Management Intent: Fire Management's contribution to Ecosystem Management will involve social and political influences. The risks that surround prescribed fire applications and the complex issues inherent in managing fire-adapted ecosystems sharpen the potential for conflict. The agency needs to more completely develop and communicate the scientific rationale behind management of fire-adapted ecosystems. It also needs to explain the long-term consequences of avoiding treatment in these systems. Further, we must ensure that our policies are consistent with Ecosystem Management and have scientific foundation.

Tools Required:

1. Information and education program that explains fire's ecological role.
2. Demonstration areas that display fire's ecological role.

Action Plan:

- Conduct a review of all Fire Management policies to ensure that they are founded on scientific principles. Include all disciplines (prevention, suppression, prescribed fire use, fuels management, fire rehabilitation, external relations, and planning).

  Director of F&AM. 10/1/93.

- Washington Office Fire Management and Public Affairs Staff work with regions to develop regional-specific interpretive plans.

  Branch Chief, Fire Use and Fuels, Regional Fire Use Fuels Specialist, and Washington Office Regional Public Affairs Task Group. Group to develop plans and implementation schedule by 3/1/94.

- Washington Office Fire Management and Public Affairs Staff work with the Ad Council to coordinate the Smokey Bear message and reduce potential for confusion among our publics.

  Branch Chief Fire Use and Fuels, Ecosystem Management staff, Smokey Bear Coordinator, and Ad Council. 3/1/94.

- Regional Fire Management work with Ecosystem Management and Public Affairs Staff groups to establish demonstration areas.

  Regional Office, Fire and Aviation Management, Ecosystem Management, Public Affairs Task Group to develop implementation plans and schedules by 3/1/94.

2. RETAIN A SERVICE AND SUPPORT ORIENTATION WITHIN THE FIRE MANAGEMENT COMMUNITY, BUT TAKE AN EARLIER, MORE ACTIVE ROLE IN THE LAND MANAGEMENT PLANNING PROCESS.

Integrate fire related considerations into forest plan alternatives, goals, and objectives. Include display of long-term effects associated with fire use and fire protection programs on attainment of forest plan objectives, and

Document effects of implementation in the monitoring and evaluation phase of forest plan execution.

Management Intent: The land management planning process is the institutional mechanism best suited to display complex dilemmas in integrating fire into Ecosystem Management. On the whole, fire related considerations having an ecological basis and reflecting long-term tradeoff analysis were largely absent from the first generation of Forest Plans. In order for our publics and our decision makers to have benefit of the information required to make informed judgements—particularly in fire-adapted ecosystems—Fire and Aviation Management needs to be better represented in future land management planning efforts.

Fire Managers will require skills that enable them to:

- Inventory and interpret historic and existing forest composition, structure, and function.
- Predict the most likely future forest stand conditions over time, given the current situation and probable susceptibility to insect, disease, and fire.
- Estimate possible range of future forest stand conditions that are sustainable, given likely disturbance factors, including insects, disease, and fire.
- Develop management goals and objectives that alter an existing undesirable present condition (or predicted successional pathway) to a more desirable future condition.
- Develop management goals and objectives for fire protection which are in concert with ecological processes.
- Develop management goals and objectives that allow ecological processes to function, resulting in a condition that is sustainable.
- Implement a monitoring and evaluation process that facilitates learning while it assesses success, progress, or shortfalls in sustaining fire-adapted ecosystems (both in protecting them and in maintaining them through fire use).

Tools Required:

1. Ecological classification system that recognizes the effects of fire disturbance.
2. Fire based risk assessment process that describes how species composition and stand structure characteristics influence risk in short interval fire-adapted ecosystems.
3. Long-term trade-off analysis techniques that display how risks, consequences, and management options change over time.
4. Social and economic impact methods that enable planners to anticipate management induced change and mitigate undesirable effects.
5. Standard monitoring and evaluation techniques that measure and document the effects of fire control and fire use programs on forest health conditions in fire-adapted ecosystems. Include provision to evaluate the full long-term ecological effects of air quality requirements and other regulatory programs (Clean Air Act, Clean Water Act, Endangered Species Act, and so forth).

Action Plan:

- Washington Office Fire and Aviation Management develop letter for Deputy Chief's (S&PF) signature encouraging regions to include fire representation on Ecosystem Management interdisciplinary and forest planning teams where not currently in place. Attach staffing paper "Fire Related Considerations and Strategies in Support of Ecosystem Management."

  Branch Chief, Fire Use and Fuels. 5/1/93.

- Washington Office Fire Management work with Land Management Planning staff to require analysis of fire protection and fire use programs in attainment of forest plan objectives (FSM 1922.21c).

  Branch Chief, Fire Planning. Proposed 7/92.

- Washington Office Fire Management work with Forest Fire and Atmospheric Sciences Research staff and regions to develop analysis tools tailored for regional application.

  Undetermined responsibility. 1/1/94.

- Washington Office Fire Management establish national-level training curricula for fire related decision support in the land management planning process.

  Undetermined responsibility. 1/1/94.

- Regional Fire Management develop guidebooks to facilitate inclusion of fire related considerations into forest plans. See appendices B-D.

  Regional Fire Use/Fuel Specialists and Regional Fire Planning Specialist. 3/1/94.

- Washington Office Fire Management support advanced studies in fire sciences. Establish graduate level degree programs in cooperation with universities. Use completion as a consideration for advancement in fire management.

  Undetermined responsibility. Undetermined completion date.

- Washington Office Fire Management work with Forest Fire and Atmospheric Sciences Research staff and regions to develop a self-study and short course curricula that broadens awareness of fire ecology principles for fire managers, Line Officers, and those involved in forest planning. Require completion for managers having responsibilities in short interval fire-adapted ecosystems.

  Undetermined responsibility . Undetermined completion date.

3. CONTINUE TO STRENGTHEN THE CONCEPT OF TOTAL FIRE MANAGEMENT BY INCREASING PRESCRIBED BURNING EXPERTISE WHILE MAINTAINING STRONG FIRE SUPPRESSION CAPABILITIES.

Management Intent: Fire protection capabilities will need to remain strong as fire-adapted ecosystems continue to approach high risk ` conditions and as private development continues to expand at the wildland/urban interface.

Simultaneously, however, Fire Management needs to strengthen prescribed burning capabilities and reassess positions on risk taking. Prescribed burning skill development needs emphasis.

Tools Required:

1. Current fire suppression skills and experience.
2. Prescribed fire behavior analyst skills.
3. Prescribed burning experience.
4. Reward system recognizing responsible risk-sensitive prescribed burning achievements.

Action Plan:

- Washington Office Fire Management will continue its emphasis on a quality protection program, including fire suppression.

  Assistant Director for Operations. Continuing.

- Washington Office Fire Management to recommend that Ecosystem Management develop task team to reassess agency posture on risk and risk taking.

  Director of F&AM. 6/31/93

- Washington Office Fire Management work with regions to develop common self-study and short course curricula that broadens awareness of prescribed fire principles for line officers having burn plan approval authority.

  Branch Chief, Fire Use and Fuels with Regional Fire Use/Fuels Specialists. 1/1/94

- Washington Office Fire Management support Technical Fire Management (TFM) and Continuing Education in Fire Management (CEFM) course work. Use completion as a consideration for advancement in Fire Management.

  Branch Chief, Fire Use and Fuels with Regional Fire Use/Fuels Specialist. 1/1/94

- Washington Office Fire Management support the prescribed fire academy concept to train and refresh prescribed fire practitioners. Re-establish regional exchange programs to develop prescribed burning and fire management skills.

  Branch Chief, Fire Use and Fuels with Regional Fire Use/Fuels Specialists. 1/1/94.

- Washington Office Fire Management institutionalize a prescribed fire certification program. Use certification as a consideration for advancement in Fire Management.

  Prescribed Fire and Fire Effects Working Team (NWCG) has work in progress.

- Washington Office Fire Management work with regions to establish annual Chief's and Regional Foresters awards for achievements in prescribed fire programs and projects.

  Branch Chief, Fire Use and Fuels, Regional Fire Use/Fuels Specialists, and personnel management task group. Undetermined completion date.

4. INSTITUTIONALIZE AN OPERATIONAL RISK ASSESSMENT AND MITIGATION STRATEGY AT THE LOCAL LEVEL IN SUPPORT OF PRESCRIBED FIRE TREATMENTS. INCLUDE A DETERMINATIN OF ESCAPE THRESHOLDS AND IDENTIFICATION OF HIGH RISK FACTORS THAT TRIGGER OR CONTRIBUTE TO ESCAPED PRESCRIBED FIRES.

Management Intent: Operational risk management needs to become a cornerstone of the prescribed fire program. A risk assessment process must become the basis for the go/no-go decision. Managers must know and avoid high-risk prescribed burning treatments, unless they can be adequately mitigated. Fair, timely reimbursement must be provided the public in the event of prescribed fire escapes.

Tools Required:

1. Prescribed fire risk assessment process, including public involvement practices that incorporate risk perception standards and procedures.
2. Prescribed fire data base using appropriate technology (e.g., NFDRS) to catalog escape factors and identify go/no-go thresholds.
3. Risk recognition guide for use by fire practitioners.
4. Means for fair, timely restitution of damage claims resulting from prescribed burning escapes.
5. Mechanisms for developing external partnerships that share prescribed fire risk in pursuit of Ecosystem Management objectives.

Action Plan:

- Washington Office Fire Management work with Timber Management and Land Management Planning staffs to develop economic feasibility model that can be used as a basis for understory treatments in high-risk stands.

  Undetermined responsibility. Undetermined completion date.

- Washington Office Fire Management work with Timber Management staff to facilitate industry shift to improved utilization of understory biomass. Explore feasibility of expanding electric co-generation power plants, possibly through tax credits or other economic incentives. Explore economic development and recovery opportunities.

  On going with Timber Management staff. Undetermined completion date.

- Washington Office Fire Management work with regions to establish standard regional escaped prescribed fire databases that are capable of identifying escape factors and go/no-go thresholds as a basis for future risk management applications. Washington Office provide guidance to regions to develop local risk mitigation guidelines.

  Branch Chief, Fire Use and Fuels with Research and Regional Fire Use/Fuel Specialists. 3/1/94.

- Washington Office Fire Management work with Timber Management staff and regions to develop a comprehensive understory risk mitigation plan that sets priorities on salvage entries, thinning, girdling, and other stand treatment options and directs funds for their treatment.

  Undetermined responsibility. Undetermined completion date.

- Washington Office Fire Management work with Fiscal and Public Safety staff to modify Federal tort claims process, providing for more timely reimbursement following loss to private property. Pursue revision of current authority to reimburse above $3,000.

  Assistant Director for Operations, task ongoing. Undetermined completion date.

5. MAINTAIN A PROGRAMMATIC DIVERSITY IN FIRE MANAGEMENT, BUT BETTER ALIGN PREVENTION, SUPPRESSION, HAZARD REDUCTION, FIRE USE, AND FIRE REHABILITATION EFFORTS TO MORE FULLY COMPLEMENT ONE ANOTHER IN SUPPORT OF ECOSYSTEM MANAGEMENT.

Management Intent: Wildfire and prescribed fire policies need to be maintained. However, prevention, suppression, hazard reduction, and fire use programs need to reflect a common purpose and complement one another toward a larger ecosystem health objective. Large-scale ecosystem treatments will need to be coordinated between other functions and the Fire Management program in order to remain economically feasible and socially acceptable.

Early seral stages in short interval fire-adapted ecosystems are assumed to be biologically more resilient than late successional senescent stages. For this reason, they are economically and operationally more feasible to protect and sustain over time.

Tools Required:

1. Operational Plan for Ecosystem Management. Strategically, the plan must be both deliberate and opportunistic in its approach to whole ecosystem health. The plan should be based on stand succession and include features that:
   - Direct mechanical treatments to high risk stands, attempting to modify stand structure and reduce risk.
   - Allow low impact disturbance (insect, disease, fire) to occur where planned objectives identified in forest plans are being satisfied.
   - Direct prescribed burning investments toward early successional stands where risks are relatively low, potential payoffs are high, and opportunities for treatment are widest.
   - Direct protection investments to earliest successional stands where they are developing toward desired future conditions.
2. Fiscal Plan for Ecosystem Management. The plan must provide funding and establish reporting systems for prescribed burning in support of Ecosystem Management.

Action Plan:

Washington Office Ecosystem Management staff work with regions and Washington Office Administration staffs to develop an Operation Plan and a Fiscal Plan for Ecosystem Management. Note: Provide example from Figure 11, page 26 as possible model. Undetermined completion date.

Summary

We have much to learn about fire's role in many vegetative types, but fire ecology relationships in long-needle pine and other short interval fire-adapted ecosystems have been well established. Fire plays an essential role in sustaining these ecosystems but has not been recognized as a fundamental ecological disturbance process when developing management policies and practices.

Sustaining fire-adapted ecosystems is emerging as an important agency challenge. However, given the complex, contentious issues that surround fire use there is continuing uncertainty over the role of fire and our ability to sustain these ecosystems. Paradoxically, although there is some growing recognition of fire's role in these ecosystems, there is a diminishing social tolerance for smoke and other adverse effects that accompany burning. Also, there are fewer dollars available to finance the cost of treatment.

The consequences of excluding periodic low-intensity fire in these ecosystems is not without serious risk, as forest health problems throughout the west bear out. Air quality standards, risk avoidance, and competition between functional interests often preclude the use of prescribed fire. But, no matter how well-intentioned, these reasons may overlook the larger issue of ecosystem health.

Larger scale prescribed burning in short interval fire-adapted ecosystems is biologically appropriate and consistent with Ecosystem Management principles. Sustainability— a satisfactory social, economic, and biological solution—will remain elusive until there is a better conceptual understanding of the long-term risks and consequences of fire control and fire use alternatives in these systems.

Staffing Group and Contributors

Staffing Group

Jerry T. Williams	FS	Washington Office	F&AM
R. Gordon Schmidt	FS	Pacific Northwest Region	A&FM
Rodney A. Norum, Ph.D.	NPS	BIFC	FM
Phillip N. Omi, Ph.D.		Colorado State University	
Robert G. Lee, Ph.D.		University of Washington	

Contributors/Reviewers

Robert W. Mutch	FS	Intermountain Fire Sciences Laboratory
Roger L. Eubanks	FS	Southern Region
Michael S. Edrington	FS	Pacific Northwest Region, Mt. Hood National Forest
James K. Brown, Ph.D.	FS	Intermountain Fire Sciences Laboratory
Stephen F. Pedigo	FS	Washington Office
John W. Chambers	FS	Intermountain Region
Gene W. Benedict	FS	Intermountain Region, Payette National Forest
Mary Paulson	FS	Pacific Northwest Region

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Appendices

APPENDIX A. Schematic showing relationship between social, economic, and biological considerations in reaching sustainability.

APPENDIX B. Fire planning processes in support of Ecosystem Management.

APPENDIX C. Relationship between ecological classification, climate, and historically determined fire regime.

APPENDIX D. Decision support/display methodology.

APPENDIX E. A historical summary of fire in ecosystems and fire management in the United States.

APPENDIX G. Glossary

NOTE: Regional examples are sometimes used to illustrate concepts. Although the examples may suggest a limited application, the concepts that they illustrate apply nationally.

Analysis and decision methods described in this paper are standard techniques.

APPENDIX A. Schematic showing relationship between social, economic, and biological considerations in reaching sustainability.

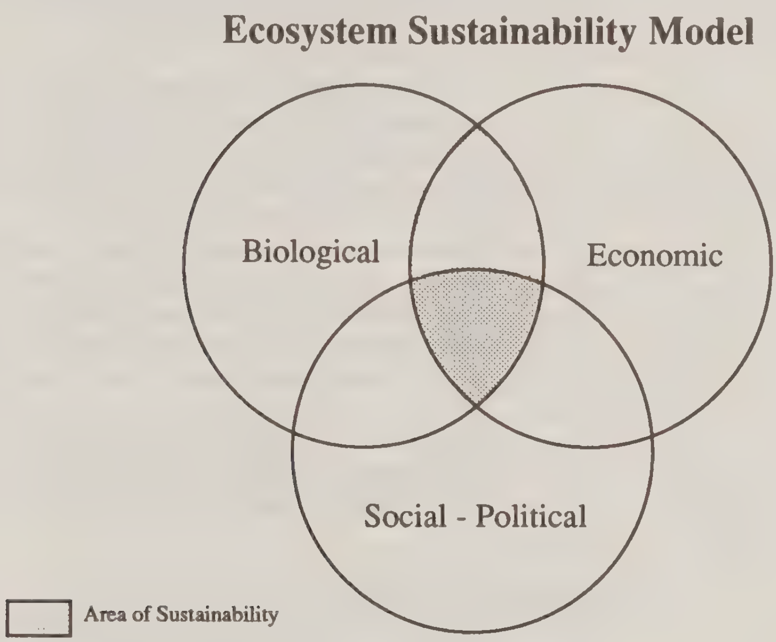


Figure 2. Ecosystem Sustainability Model

To be sustainable, Ecosystem Management must meet three conditions. It must be:

- Biologically possible in the long run
- Economically gainful enough to motivate short-range commitments to productive activities, and
- Socially and politically acceptable (fall within the bounds assigned to public lands).

Sustainability becomes possible where these three conditions overlap. Ecosystem Management provides a way of specifying what is biologically possible in the long run. Past fire management practices have been socially and politically acceptable but exceptionally costly and uninformed about the long-term biological consequences. Future practices can be improved substantially by giving explicit consideration to all three conditions when making forest planning and management decisions.

APPENDIX B. Fire planning processes in support of Ecosystem Management.

Fire related analysis will be integrated with the land management planning process. Manual requirements for Fire Management in development of forest plans (FSM 1922.21c, proposed 7/92):

> *The Forest Plan shall provide the basis for wildfire suppression responses, pre-suppression activities, post-activity fuel profiles, and the use of natural or prescribed fire to promote the accomplishment of forest-wide and/or management area objectives (FSM 5100).*
>
> *When developing resource management direction consider the historic and natural role of fire within the forest ecosystem. Consider also the relationship of prescribed fire and the long term consequences likely to result from fire suppression on achievement of sustainable multiple-use goals and objecives.*

Sustainability is a key element of Ecosystem Management and is a part of the agency's legislated mandate under the Multiple Use Sustained Yield Act (1960). Its use infers the importance of long-range evaluation and long-term tradeoff analysis.

Forest plan objectives are concise statements which describe a specific result or condition desired in order to achieve a broader goal. The concept of a Desired Future Condition is a useful means to portray the land or resource conditions that are expected to result if goals and objectives are fully achieved.

In developing forest plan goals and objectives, the role of fire management is to:

- Estimate and display the long-term risks and tradeoffs from among the range of alternatives used in shaping forest plan objectives, including the fire exclusion alternative.
- Frame development of forest plan objectives in the context of fire behavior characteristics common to the fire regime for an area.
- Provide technical fire related support to land management decisions to assure that forest plan objectives and intermediate fire treatment activities in support of their eventual development are technologically feasible and within acceptable limits of risk, given economic constraints.

In the development of forest plan objectives, it is essential that alternatives be evaluated in the context of sustainability. *Each alternative must display the long-term effects likely to occur as a result of implementation of that alternative*. Although some alternatives may appear infeasible (socially, legally, or economically), the long-term consequences of avoiding implementation may preclude the agency's ability to ensure sustainability. For example, alternatives requiring prescribed burning may appear infeasible because of a social intolerance for smoke, but, if not included as an alternative, other biological (and perhaps larger social) consequences may be overlooked. If the full range of alternatives is not subjected to evaluation, the cost (social, economic) of meeting objectives (e.g., sustainability) may not be apparent. A similar consequence may result from the selection of a superficially attractive alternative, if potential long-term ramifications are not explored.

Although any alternative may be dismissed because of short-term social, legal, or economic considerations, it is ecologically important that long-term consequences be known and reflected in the monitoring and evaluation phase of forest plan implementation. *Constraints (social, legal, economic) should shape, but not displace, objectives in the evaluation phase of alternative development.*

Implicitly, objectives must be attainable. In fire-adapted ecosystems, the feasibility of forest plan goals and objectives should be predicated on fire behavior characteristics: past, present, and expected. The stand's present and projected flammability potential and the ecosystem's resilience to perturbation at those intensity levels is a key consideration in development of attainable forest plan objectives. In a sense, the development of forest plan goals and objectives become an iterative, interactive process where fire regimes and fire dynamics for a given area help decide the Desired Future Condition. The measure of an objective's Fire Management feasibility should be expressed in terms of ecologic amplitude and the desired stand's expected fire behavior (appendix C). Generally, if biological uncertainty surrounds a decision, the closer a Desired Future Condition is to the natural condition, the more sustainable and less cosly implementation will probably be. The tolerance of each species to fire should be a critical benchmark from which to judge the costs and risks of alternative treatment options leading to development of forest plan objectives.

Figure 3 describes fire ecology related considerations that should be included in development of forest plan objectives, while figure 4 illustrates the general planning flow.

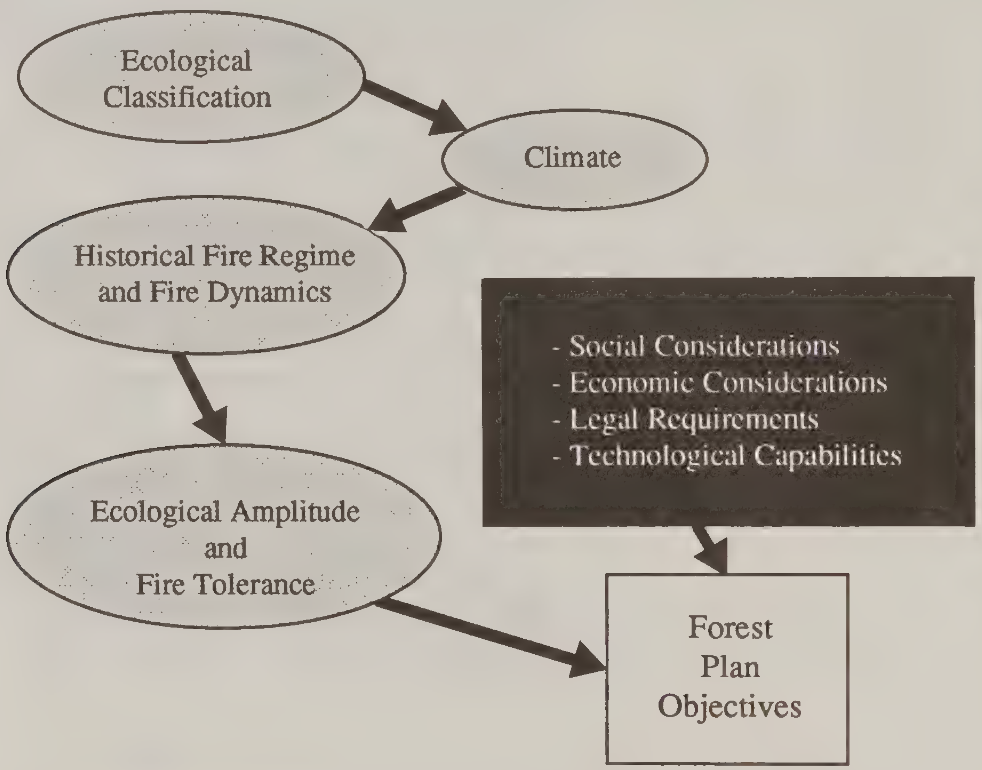


Figure 3. Relationship between forest plan objectives and the fire-related elements that go into their determination.

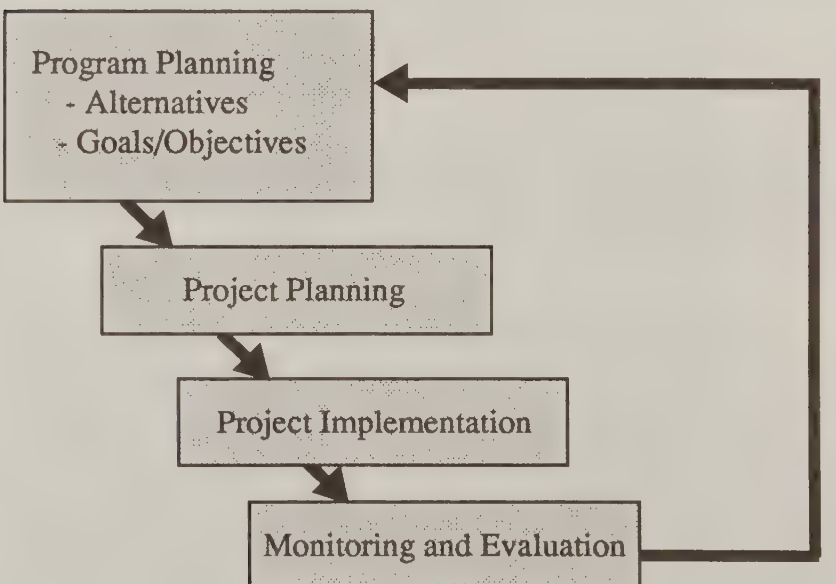
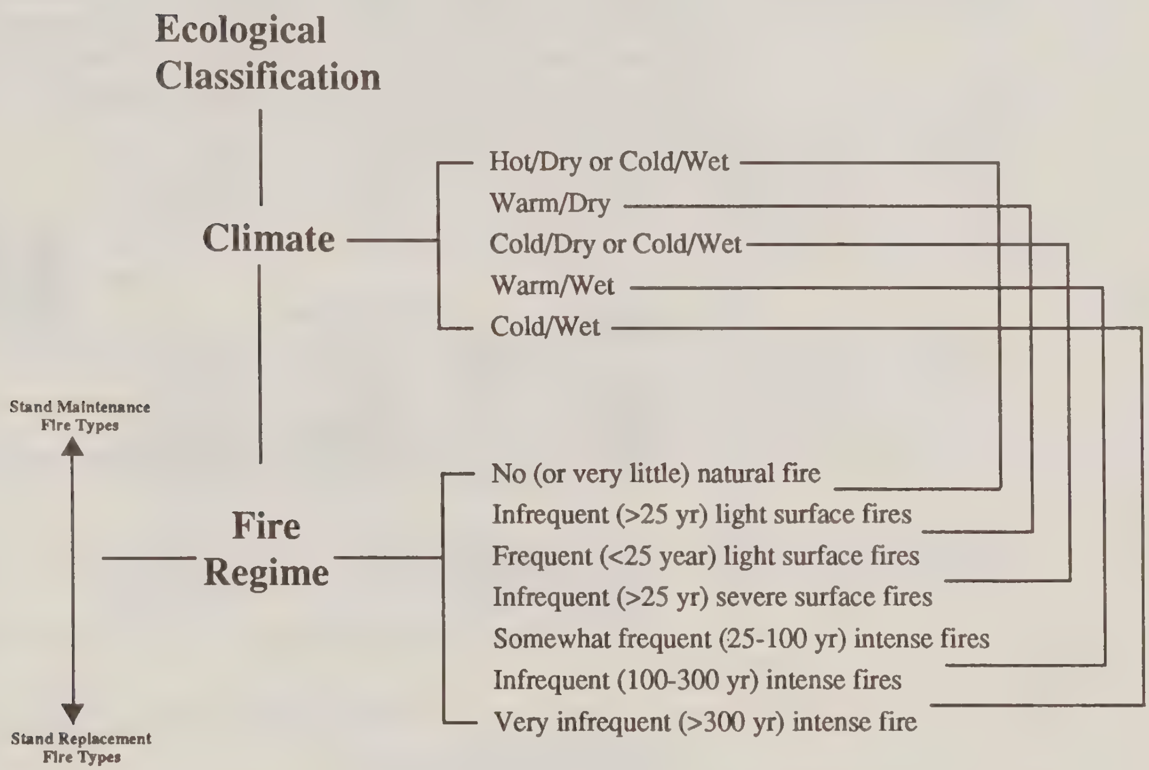


Figure 4. General Forest Planning Process

From a Fire Management standpoint, the means to develop attainable forest plan objectives finds basis in the area's ecological classification, climate, and fire regime. Appendix C displays the relationship between these three interrelated factors.

APPENDIX C. Relationship between ecological classification, climate, and historically determined fire regime.

Ecological classification systems indicate vegetative potential along a temperature and moisture gradient. In turn, this information can be used along with fire history information to determine fire regime (figure 5).



Note: This schmatic portrays general patterns in the retationship between cimate and fire regime. From Heinselman, M.L., 1978.

Figure 5. General Fire Regimes

For a given site, species composition and stand structure can be evaluated in a historical context to estimate normal ecologic amplitude and identify variation from it. Differences in species composition and stand structure—past to present—can be interpolated to estimate likely differences in fire behavior characteristics and, subsequently, the site's probable tolerance to those differences. For instance, a mature, open ponderosa pine stand with grass and litter understory on a warm, dry site would be expected to exhibit low-intensity fire behavior characteristics (Figure 6). Figure 7 illustrates an example where, presently, fire plays a stand-maintenance role, much like it did historically. The present day effect of fire would be similar to the historical effect of fire and remain within the site's ecologic amplitude.

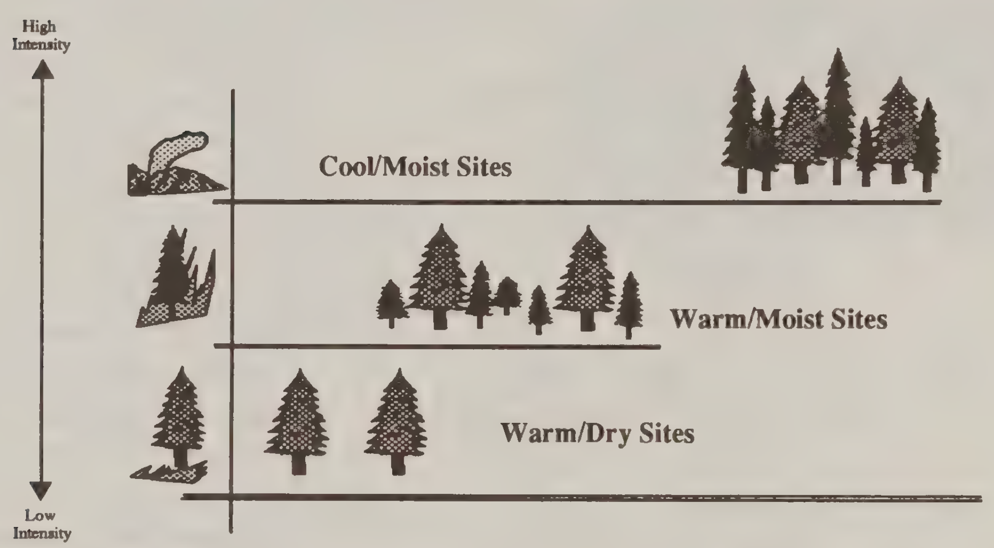


Figure 6. Comparison of ecologic amplitude and expected fire behavior between warm/dry, warm/moist, and cool/moist habitat groups.

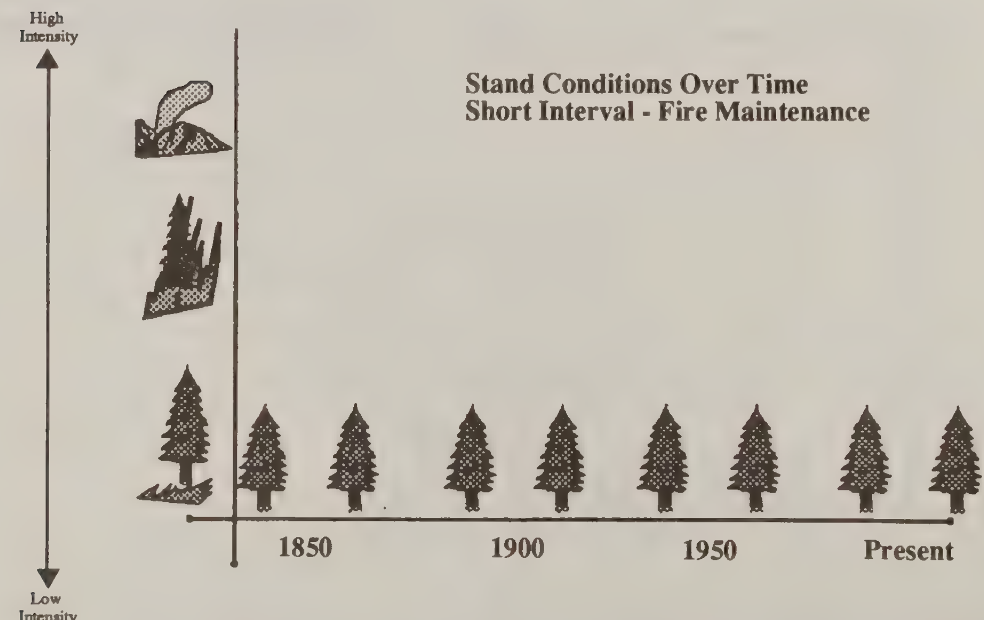


Figure 7. Stand conditions over time in a short interval, fire-adapted stnd, under fire maintenance.

By contrast, a mature ponderosa pine stand with heavy conifer encroachment (multi-storied, younger age classes dominated by older overstory) on a warm, dry site would be expected to exhibit high-intensity fire behavior characteristics. In this example (Figure 8), fire would often play a stand-replacement role, unlike it did historically. A stand-replacement fire on a site adapted to lower-intensity fire behavior may be outside of the system's or a given species' ecologic amplitude and be severe enough to interrupt sustainability or, more seriously, result in more permanent type conversion. This might more typically occur on an ecotone.

The use of climate and fire regime information helps determine the ecological limits influencing development of attainable forest plan objectives and Desired Future Condition. In fire-adapted systems, fire behavior characteristics associated with various management alternatives can be compared to those probably existing historically and judging the degree of variation within each.

In the examples described, on sites characterized by fire regimes exhibiting frequent, low-intensity fire, a lighter, more open-grown stand condition becomes a more ecologically feasible forest plan objective (Figure 7). Because it is within the system's ecologic amplitude, it has a higher probability of remaining sustainable on warm/dry sites.

Fire behavior consequences on warm/dry sites clearly indicate that, as stands develop in the absence of fire, we can anticipate more intense fire behavior (Figure 8).

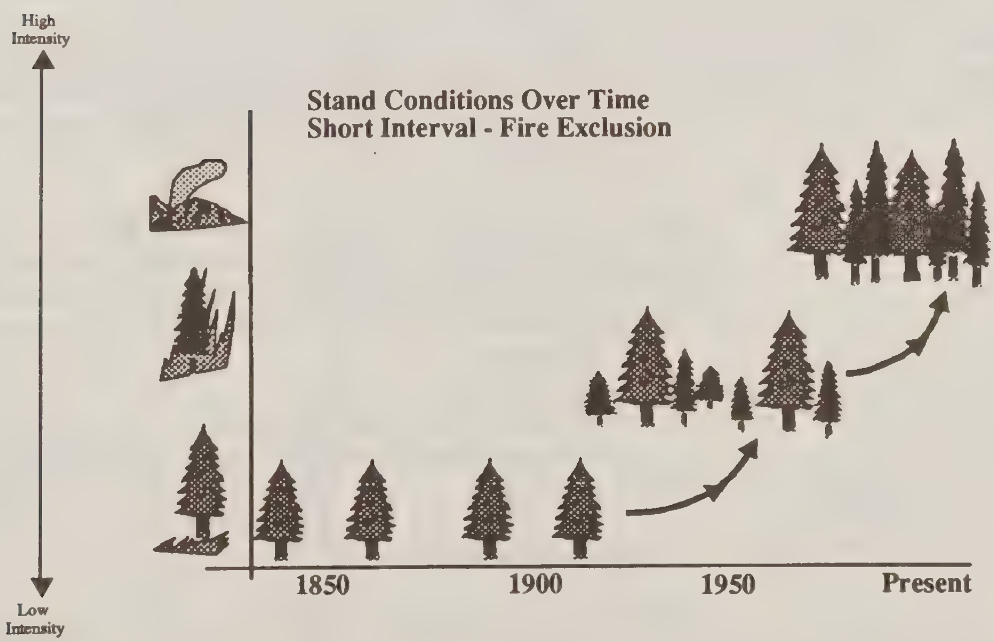


Figure 8. Stand conditions over time in a short interval, fire-adapted stand, following fire exclusion.

APPENDIX D. Decision support/display methodology.

In the development of forest plan objectives, decision trees (future option models) are essential tools used to display and communicate expected benefits, risks, and consequences that might result from any alternative under consideration. By way of illustration, an example is used to show the utility of these tools.

Example scenario: The stand conditions for this example are illustrated in Figure 8. Since the early 1900's, fire has been excluded from a short interval fire-adapted stand on a warm/dry site that was once maintained by frequent, low-intensity fire. Historically this stand exhibited open stand structure characteristics and was dominated by ponderosa pine. The stand's present condition includes ponderosa pine remnants, but the understory is occupied by encroaching Douglas-fir, the late seral species. The stand is multi-storied and uneven aged with relatively few overstory trees. The understory is represented by generally depauperate trees. Nutrient cycling is slow.

The treatment alternatives that are possible for this stand are described below. Each alternative carries distinctly different risks. An adjective rating (low, moderate, high) accompanies the decision tree diagram (Figure 9). The adjective ratings describe the probability of succession developing as illustrated, given the stand's climatic influences, fire regime/fire dynamics, and tolerance to fire at expected fire intensities.

Alternative 1: Mechanical understory reduction with fuel treatment. This alternative uses pre-commercial thinning to reduce the number of understory trees. It follows mechanical thinning with prescribed underburning.

Alternative 2: Mechanical understory reduction without fuel treatment. This alternative uses pre-commercial thinning to reduce the number of understory trees. It relies on natural abatement to reduce fuel hazard.

Alternative 3: Unmanaged stand condition. This alternative does not treat the stand. Although this example does not show it, chances for "opportunistic management" may present themselves following disturbance. However, activities are not programmed under this alternative.

Alternative 4: Prescribed burning at 15-year intervals. This alternative uses prescribed fire only to reduce understory stocking and surface fuel loadings.

Six steps describe the process:

Step 1 establishes the historical, present, and projected alternative scenarios.

Step 2 establishes a range of functional Desired Future Conditions among forest plan goals and objectives. This occurs in an interdisciplinary team setting.

Step 3 evaluates the range of variability between Desired Future Condition alternatives and the historically established stand for feasibility and sustainability.

Step 4 takes the Desired Future Condition that best remains within ecologic tolerances for the site, choosing from among stand conditions along each treatment alternative illustrated in the decision tree.

Step 5 evaluates the economic (treatment costs), social (productivity), and biological (sustainability, diversity) consequences of each choice. This step uses the adjective probability estimates to help guide the decision.

Step 6 represents interdisciplinary and public consensus.

The decision tree analysis (figure 9) will assume that historical weather patterns will recur. It will also assume that, under some conditions, insects, disease, and fires will recur. Although the permutations possible under each alternative are endless, this example will focus on the most probable scenarios normally expected to occur, within 50-year intervals. Assume that management treatments prescribed for an alternative are successful. The scenarios are not absolute in terms of accuracy; instead, they are approximations that use observed responses in similar stands on similar sites, given similar patterns of disturbance. They also rely on professional judgment.

An important element of decision tree analysis is the full display of potential opportunities, including the pathways that may result in lost future options. Each stand, having reached some stage, has fewer possible pathways available. Eventually, foregone opportunities develop where, despite management actions, an inevitable event occurs. Management goals normally seek to avoid situations where the possible pathways remaining in a stand's successional development result in loss or undesirable type conversion.

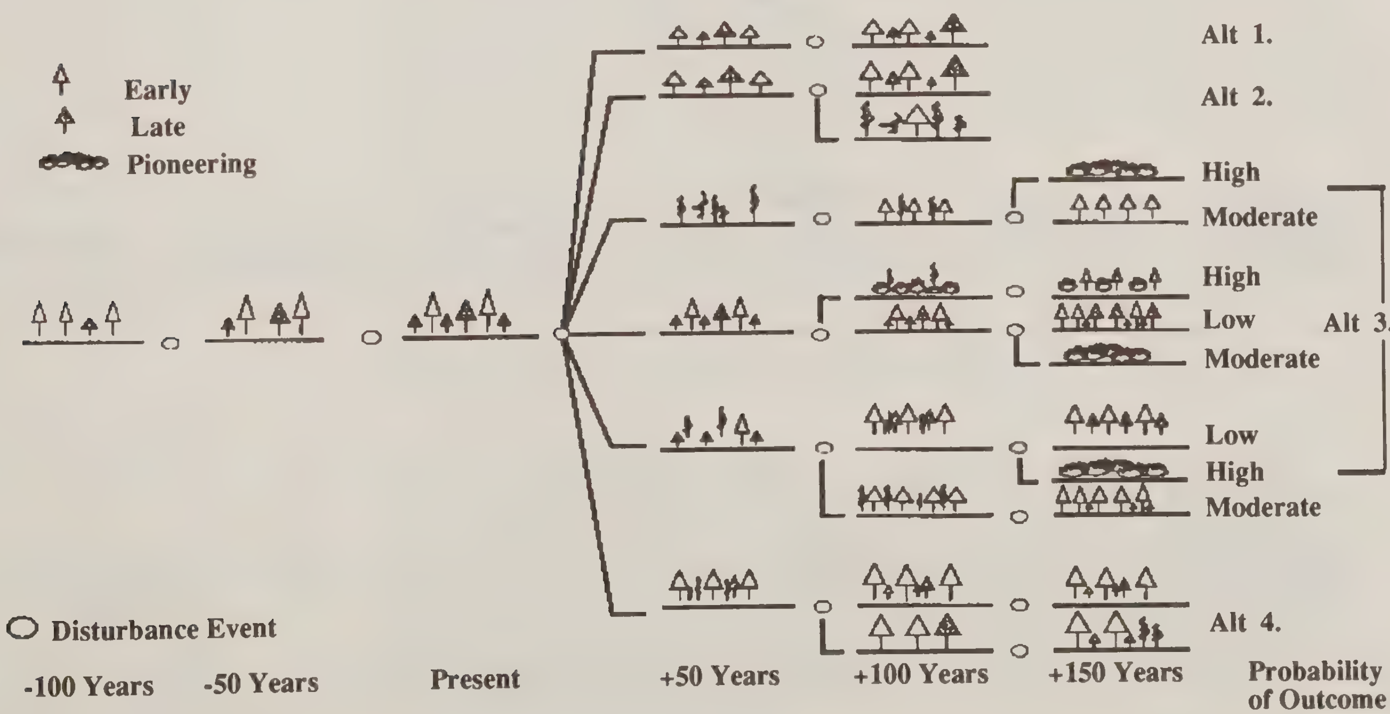
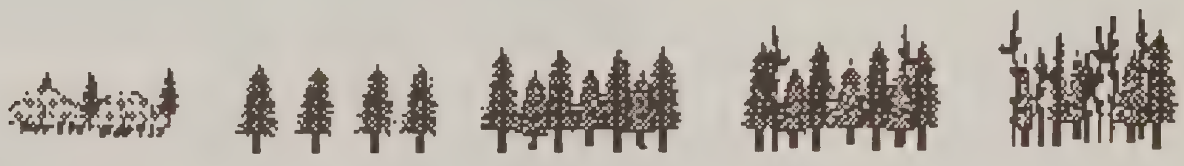


Figure 9. Decision Tree and Risk Assessment

The mix of these opportunities define, on a landscape basis, the Desired Future Condition of an ecosystem as illustrated in Figure 10.

Defining Desired Future Condition



	Pioneering	Early Seral	→	Late Seral	Senescent
Estimated Natural Proportion	10%	60%	15%	10%	5%
Current Proportion	5%	10%	30%	40%	15%
Desired Future Condition	?	?	?	?	?

Figure 10. Example of Natural and Current Distribution by Successional Stage (short interval fire adapted ecosystem).

SUCCESSIONAL STAGE	Pioneering	Early Seral	→	Late Seral	Senescent
FOREST PRACTICES EMPHASIS	Protection	Prescribed Fire Maintenance	Mechanized Resstoration	Opportunistic Resstoration	→

RELATIVE INVESTMENT CONSIDERATIONS	HIGH EXPECTED LOSS	↔	LOW EXPECTED LOSS

Firgure 11. Possible Forest Practices Emphasis Consistent with Ecosystem Management (short interval fire adapted ecosystems)

APPENDIX E. A historical summary of fire in ecosystems and Fire Management in the United States.

Fire protection was among the earliest legislated mandates given to the Forest Service after severe wildfires near the turn of this century. Some of the most serious conflagrations were the result of frontier woods burning, where the casual use of fire was seen as an expedient means to clear land or reduce brush. The 1871 Peshtigo Fire, fueled by logging slash, burned over 3.5 million acres and killed some 1,500 people in Wisconsin and Michigan. In 1910, the Great Idaho/Montana Fires burned another 3.0 million acres and leveled whole towns, this time burning in natural, unharvested forests. These early fire disasters were costly and, in the public eye, unacceptable. Federal fire control policies evolved as a result of these disasters and were in direct response to public expectations of the time.

Aggressive fire suppression policies quickly showed positive results. The average size per fire dropped steadily from over 300 acres in 1917 to less than 30 acres 50 years later. However, as a result of fire exclusion, a subtle change in forest health began to take place as natural processes were disrupted. This became most visibly evidenced in fire-adapted ecosystems.

Early fire disasters made it difficult for most foresters to recognize that fire could be anything other than damaging. However, although destructive fires continued to occur, some forest managers began to notice that, in some stands, light surface fires had beneficial effects. Neverthless, efforts to use fire, rather than fight it, ran contrary to conventional thinking and appeared to be in conflict with the land management mandate given the Forest Service. Within the agency, there was a strong sense of obligation toward fire protection and the legal responsibility to eliminate woods burning that typified frontier exploitation at the turn of the century.

Eventually, fire use policy began to take shape when burning could be managed and controlled, rather than simply used and left to chance. The concept of prescribed burning began to emerge. It was not woods burning; it was defined as carrying specific objectives and being applied by skilled practitioners. Over the next several years, prescribed fire applications increased, especially in the southeast. By the late 1970's the Forest Service formally moved from an era of fire control to an era of fire management.

Although the fire management concept recognizes the importance of protecting resources from wildfire and takes appropriate suppression action as needed, it also recognizes the importance of prescribed fire in maintaining healthy forests. Fire management considerations are an important component in support of many of the land management plans that direct Forest Service activities. Today, prescribed fire is a vitally important resource management tool across most National Forests.

Fire has obvious, sometimes dramatic results, but it is often the more subtle effects that are the most significant in terms of maintaining healthy ecosystems capable of sustaining resource outputs. Fire has an important effect on soil fertility, insect populations, spread of disease, plant succession, and stand vigor. Periodic burning maintains fire-adapted seral stands by reducing fuel accumulations and the subsequent potential for severe stand replacement fires. In fire-adapted ecosystems, the complex effects of burning cannot be replicated by mechanical or chemical means.

Although Forest Service policy recognizes the ecological importance of fire, a serious dilemma precludes the agency's ability to effectively manage fire-adapted ecosystems. The adverse effects and occasional damage that results from prescribed fire failures are poorly tolerated by the public and frequently embarrass the agency. Smoke, charring, and other short-term impacts are not generally acceptable to the public. Also, Federal tort claim requirements often delay timely restitution in the event of damage to private property, further eroding public support for prescribed burning. Efforts to expand prescribed burning programs are frequently met with significant resistance and constraining regulatory obstacles, particularly in areas where human populations have increased near wildland settings. The most important benefits of fire are often long-germ, biologically complex, and largely inconspicuous. As a consequence, they are seldom valued by the general public.

In the absence of fire, forest insect and disease problems periodically become epidemic, causing mortality that disrupts sustained-yield rotations and other resource management objectives. Fire exclusion has contributed to an accumulation of fuels and changes in stand structure that make many fire-adapted stands more flammable and highly susceptible to severe, stand-replacement burning. Both the control of wildfire and use of prescribed fire have become considerably more difficult as a result of these changes.

The costs and the risks involved in an extensive reintroduction of fire will be high. The use and enjoyment of National Forest System lands has grown tremendously over the past several decades. These rising values, combined with unnaturally flammable fuel conditions and the enormous uncertainties surrounding wildland burning, severly constrain prescribed fire applications that can be managed within acceptable limits of risk. Risk mitigation and its accompanying cost will be an essential element of a forest health strategy which relies on prescribed fire.

Certainly, a significant issue accompanying the Ecosystem Management concept now embraced by the Forest Service will focus on finding balance between social values and ecologically sound forest management strategies. Perhaps one of the single most important forest management issues that the Forest Service and its public will have to confront over the next several years will center on the question of sustaining fire-adapted ecosystems. Despite public intolerance for smoke, program costs, risk of escape, and apprehensions that surround prescribed burning, fire remains a fundamentally important ecological process in most grassland, shrubland, and forest types throughout the country. The Forest Service is committed to displaying the long-term biological and economic consequences associated with excluding fire's natural role. It is also committed to exploring the means toward resolution of these dilemmas.

APPENDIX F. Glossary

DESIRED FUTURE CONDITION:
A portrayal of the land or resource conditions which are expected to result if goals and objectives are fully achieved (draft 36 CFR 219).

ECOLOGY:
The science of the interrelationships between organisms and their environments.

ECOLOGIC AMPLITUDE:
The range of tolerance to environmental conditions of an organism or species. The magnitude of the displacement of a wave from its mean.

ECOLOGICAL PROCESS:
The actions or events that link organisms and their environment, such as predation, mutualism, successional development, nutrient cycling, carbon sequestration, primary productivity, and decay (from Webster's dictionary adapted to ecology).

ECOSYSTEM:
The complex of a community of organisms and its environment functioning as an ecological unit in nature (Webster's dictionary).

ECOSYSTEM MANAGEMENT:
The careful and skillful use of ecological, economic, social, and managerial principles in managing ecosystems to produce, restore, or sustain ecosystem integrity and desired conditions, uses, products, and services over the long-term.

ECOSYSTEM SUSTAINABILITY:
The ability to sustain diversity, productivity, resilience to stress, health, renewability, and/or yields of desired values, resource uses, products, or services from an ecosystem while maintaining the integrity of the ecosystem over time.

FIRE-ADAPTED ECOSYSTEM:
An ecosystem with the ability to survive and regenerate in a fire prone environment.

FIRE DYNAMICS:
A description of how a stand's potential fire behavior develops through the fire season in response to increasing fire danger. Usually a relative representation in graph form (Williams and Rothermel, 1992).

FIRE REGIME:
A description of (1) fire type and intensity (e.g., crown or surface fire), (2) size or area of typical significant fires, and (3) frequency or return intervals typical for specific land areas and for major fires in a region (from Heinselman 1978). For purposes of current discussion, seasonality of fire recurrence (or significant deviations therefrom) may be important for consideration.

INTEGRATED RESOURCE MANAGEMENT:

The simultaneous consideration of ecological, physical, economic, and social aspects of lands, waters, and resources in developing and carrying out multiple-use, sustained-yield management.

LANDSCAPE:

An area composed of interacting and inter-connected patterns of habitats (ecosystems) that are repeated because of the geology, landform, soils, climate, biota, and human influences throughout the area (adapted from Forman and Godron, 1989). Landscape structure is formed by patches (stands or sites), connections (corridores and linkages), and the matrix. Landscape function is based on disturbance events, successional development of landscape structure, and flows of energy and nutrients through the structure of the landscape. A landscape is composed of watersheds and smaller ecosystems. It is the building block of biotic provinces and regions.

LANDSCAPE ECOLOGY:

The body of knowledge pertaining to the ecological effects of spatial patterns in ecosystems.

MONITORING:

To watch, observe, or check, especially for a specific purpose, such as to keep track of, regulate, or control (Webster's dictionary). Successful monitoring and evaluation is dependent on the use of appropriate, predetermined indicators.

SENESCENT:

The biological state of plant growth (phase) between full maturity and death, characterized by an accumulation of dead, woody material (adapted from Webster).

SUSTAINABILITY:

The ability to maintain a desired condition or flow of benefits over time (adapted from Webster, see also Cordray and Gale; Journal of Forestry, 1991).